

**Pennsylvania Water Resources Research Center,
Penn State Institutes of Energy and the
Environment
Annual Technical Report
FY 2007**

Introduction

The FY 2007–08 Annual Report for the Pennsylvania Water Resources Research Center at Penn State University includes information about three research projects and one technology transfer project supported by the 104B base funding program. Base funded projects are competitively awarded, one–year, exploratory or seed grants related to some critical water resource need for Pennsylvania. The technology transfer project led by Bryan Swistock with the School of Forest Resources at Penn State illustrates the power of using these small 104B grants in cooperation with county agricultural extension personnel for education of rural private water system owners. This project led to the development and testing of an online video course with six lessons, a new groundwater publication available online, and a 30–min DVD video about private water system management. One of the research projects included in the report was an exploratory study of how fiber–optic distributed temperature sensing cables can be used to study groundwater contributions to stream baseflow and nitrate by Dr. Kamini Singha with the Department of Geosciences at Penn State. Dr. Singha developed new ways of analyzing and presenting fiber–optic temperature data which can be used to pin–point locations where significant groundwater and nitrate inputs occur in streams. Drs. W. Burgos, J. Senko, and M. Bruns all from Penn State report on their work to elucidate microbially mediated geochemical processes associated with oxidative removal of iron from acid–mine drainage waters. They report that abundant dissolved oxygen, low abundance of algae and presence of specific oxidizing bacteria favored oxidative iron removal at an AMD site. Finally, in the third research project, Dr. Metin Duran with Villanova reports on results from field testing a low cost, quick method for identifying sources of microbial pollution based upon fatty–acid methyl ester profiling. Also included in the annual report is information about a new USGS Internship between government scientists in Colorado and Dr. Michael Gooseff with Civil and Environmental Engineering at Penn State.

Research Program Introduction

None.

Effectiveness of Fatty Acid Methyl Ester (FAME) Profiling to Determine Sources of Microbial Pollution in Chester Creek Watershed

Basic Information

Title:	Effectiveness of Fatty Acid Methyl Ester (FAME) Profiling to Determine Sources of Microbial Pollution in Chester Creek Watershed
Project Number:	2007PA70B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	7th
Research Category:	Water Quality
Focus Category:	Water Quality, Surface Water, Non Point Pollution
Descriptors:	
Principal Investigators:	Metin Duran

Publication

1. Cem Unlu, 2008. Microbial water quality and sources of indicator microorganisms in Goose Creek. M.S. Thesis, Civil and Environmental Engineering Department, College of Engineering, Villanova University, Villanova, Pennsylvania.
2. Duran, M. 2008. Effectiveness of Fatty Acid Methyl Ester (FAME) profiling to determine sources of microbial pollution in Chester Creek Watershed.
3. Duran, M., Haznedaroglu, B.Z., and D.H. Zitomer. 2006. Microbial source tracking using host specific FAME profiles of fecal coliforms. Water Res. 40:67–74.
4. Haznedaroglu, B.Z., D.H. Zitomer, G.B. Hughes–Strange, and M. Duran. 2005. Whole–cell fatty acid composition of total coliforms to predict sources of fecal contamination. J. Environ. Eng., ASCE 131:1426–1432.
5. U.S. Environment protection Agency (EPA). 2000. National water quality inventory: 2000 Report to Congress. EPA–841–R–02–001.
6. U.S. Environmental protection Agency (EPA, 2006). National Section 303(d) List Fact Sheet online document at http://oaspub.epa.gov/waters/national_rept.control (accessed on February 21, 2008).

PRINCIPAL FINDINGS AND SIGNIFICANCE

1. A year-long microbial water quality monitoring at six different sampling points along Goose Creek showed that Site 1 located in Lacey Street (densely populated residential area) was the most microbiology polluted sampling site in Goose Creek. In spite of moderately lower colony forming unit (CFU) counts for Site 6 and Site 7, the CFU counts for all sampling sites were much higher than EPA permitted levels. High FC and enterococcus CFU results showed that immediate precautions should be taken to remediate microbial pollution problem of in Goose Creek.
2. Temporal stability of the known-source FAME libraries are found to be questionable suggesting that effective microbial source tracking using FAME technology requires establishing a local known-source library during and immediately before the source tracking efforts.
3. Nevertheless, source tracking results suggest that horse and dog are the dominant sources of indicator organisms in Goose Creek segment of Chester Creek Watershed.

STUDENTS SUPPORTED

1. Cem Unlu, Villanova University, MS WREE '08 (MS student)
2. Hugo R. Sindelar, IV, Lafayette College, BCE '08 (Summer intern)
3. Lauren Glose, Villanova University, BCE '11 (Undergraduate research assistant)
4. Brianne Puklin, Villanova University, BCE '10 (Undergraduate research assistant)
5. Patrick Sejkora, Villanova University, BCE '08 (Undergraduate research assistant)

PRESENTATIONS AND OTHER INFORMATION TRANSFER ACTIVITIES

None yet

AWARDS

2008 Student Research Award, Pennsylvania Water Environment Association. Hugo R. Sindelar, David Kendall, and Ryan Clark. 2008. "Testing Efficacy of FAME Profiling for Predicting Sources of Fecal Pollution"

REFERENCE

- Duran, M., Haznedaroğlu, B.Z., and Zitomer, D.H. 2006. Microbial Source Tracking Using Host Specific FAME Profiles of Fecal Coliforms. *Water Res.* 40:67–74.
- Haznedaroglu, B.Z., Zitomer, D.H., Hughes-Strange, G.B., and Duran, M. 2005. Whole-cell Fatty Acid Composition of Total Coliforms to Predict Sources of Fecal Contamination. *J. Environ. Eng, ASCE.* 131:1426-1432.
- U.S. Environmental Protection Agency (EPA). 2000. National water quality inventory: 2000 Report to Congress. EPA-841-R-02-001
- U.S. Environmental Protection Agency (EPA, 2006) *National Section 303(d) List Fact Sheet* online document at http://oaspub.epa.gov/waters/national_rept.control (accessed on February 21, 2008).

Improved quantification of stream–aquifer interactions for tracking nitrate transport along a river continuum: implementation of a cost–effective distributed–temperature sensing technology

Basic Information

Title:	Improved quantification of stream–aquifer interactions for tracking nitrate transport along a river continuum: implementation of a cost–effective distributed–temperature sensing technology
Project Number:	2007PA73B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	5th
Research Category:	Ground–water Flow and Transport
Focus Category:	Hydrology, Water Quality, Nitrate Contamination
Descriptors:	
Principal Investigators:	Kamini Singha, Fred Day–Lewis

Publication

PRINCIPAL FINDINGS AND SIGNIFICANCE

This project provided seed funding to start a long-term data collection of stream bottom temperature in the FD-36 watershed with the goals of quantifying the heterogeneity and seasonality of groundwater discharge to the first-order stream. In June of 2007, we deployed a fiber-optic distributed temperature sensor (FO-DTS) along 500 m of the stream within FD-36, and have collected continuous temperature data with resolution of 1 meter, every 5 minutes, to 0.1°C. The start of the line is near “Flume 1” in this stream, and the end of the line extends a bit beyond the “Flume 4.” The cable was destroyed in a storm in March 2008, but I have recently purchased a replacement cable which will be deployed later this summer. This project is a proof-of-concept study to explore how temperature can be used to help constrain baseflow contributions to streams in an agricultural setting. Results of this work will provide information required to quantify the and predict nutrient loading in space and time.

Because of the high temporal and spatial resolution of FO-DTS, there is a tremendous amount of data collected with these methods. Example data are shown below. We can capture the temporal dynamics of the stream warming and cooling throughout the data along the stream reach (Figure 1), and note that the timing and magnitude of the warming varies daily (Figure 2, 3). We have devoted considerable time in FY07 to determine how best to parse and visualize these data and thereby discriminate processes of interest. For example, we have looked at Fourier transform as a way to quantify the frequency content of data and identify changes in power spectrum spatially along the stream. To quantify patterns in this data set, we took the temperature data for each entire month at a given position, subtracted the average temperature at that location, and then computed the Fourier Transform. Figure 4 is a representative power spectra for components at the fundamental frequency up to frequencies three days. The majority of the amplitude lies in the component with a daily frequency, which is not surprising, as without annual data, seasonal trends will be impossible to ascertain. Additionally the magnitude of the power spectra decreases upstream, indicating that variations are less apparent near Flume 4 than Flume 1.

Stream discharge and meteorological data, including air temperature and solar radiation, were compared to the stream temperature data. Cross-correlations between these data sets were calculated, and indicate that the air temperature leads the stream temperature by approximately three hours. The solar radiation tends to lead the stream temperature by about five hours. As described in the Fourier data, the air temperature and solar radiation data show a larger correlation with the stream temperature near Flume 1 as compared to Flume 4. We are currently exploring the correlation between stream discharge and temperature. We have demonstrated that there is certainly a correlation between air temperature and stream temperature, and expect to see changes in temperature correlating with gaining and losing pieces of the stream as based on the flume data. Ongoing work aims to (1) apply the wavelet and cross-wavelet transform to further characterize the time series and correlations between them; and (2) investigate relationships between nitrate concentration and stream thermal behavior.

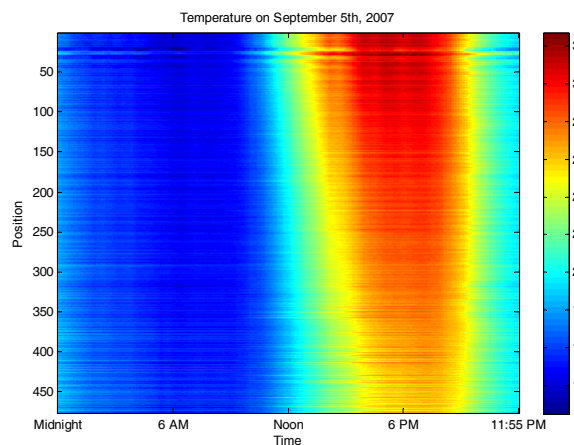


Figure 1. Temperature in °C in the stream on Sept 5, 2007. The x-axis is time during the day, and the y-axis indicates the position in m along the stream from Flume 1, going upstream.

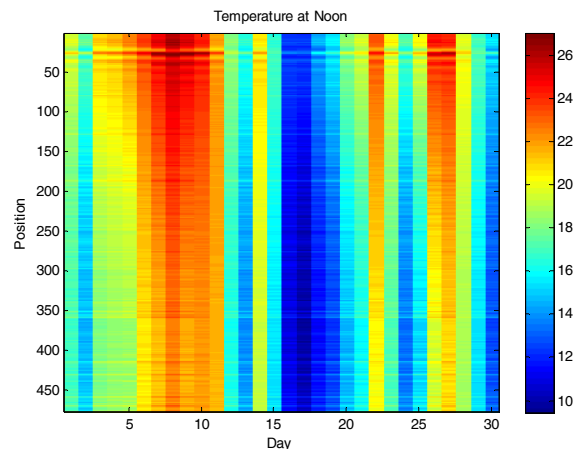


Figure 2. Temperature in °C in the stream at noon through the month of September, 2007. The x-axis is day of the month, and the y-axis indicates the position in m along the stream from Flume 1, going upstream.

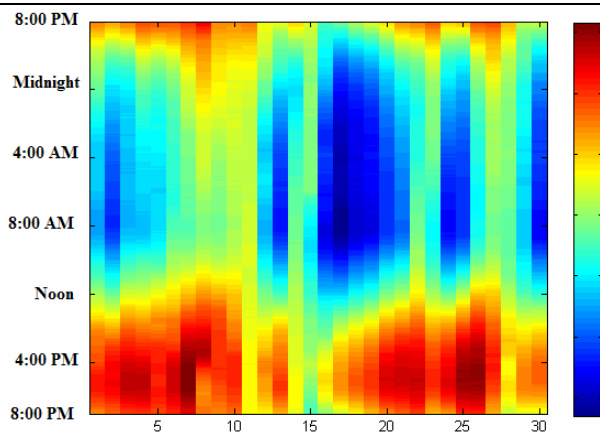


Figure 3. Temperature in °C in the stream 88 m from Flume 1 for the month of September, 2007. The x-axis is day of the month, and the y-axis indicates the time of day.

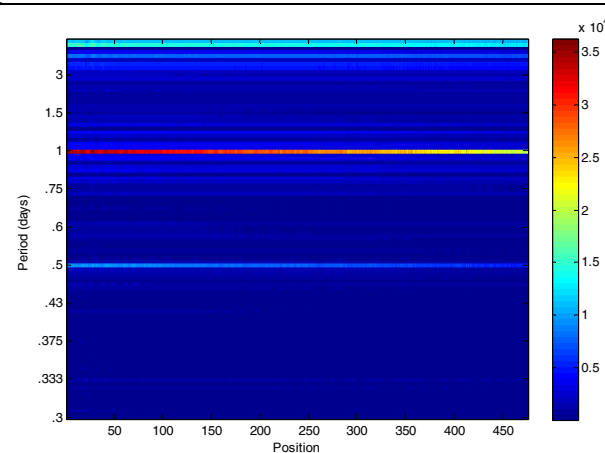


Figure 4. Fourier Transform of September temperature data. The x-axis is position in m from Flume 1, going upstream. The y-axis is the Fourier period in 1/days. The maximum amplitude occurs for 1-day cycles, and the amplitude is lower with distance from Flume 1.

STUDENTS SUPPORTED (name, major, degree)

Nicholas Rubert, Physics, Undergraduate Researcher

Ted Donovan, Geosciences, Undergraduate Thesis Student

Kristin Jurinko, Geosciences, Undergraduate Thesis Student

Brian Hamming, Geosciences, PhD student (left on medical leave just after project start, however)

PRESENTATIONS AND OTHER INFORMATION TRANSFER ACTIVITIES

Invited Talks

1. Ohio State University, School of Earth Sciences, January 2008.
2. Ecole Polytechnique Fédérale de Lausanne/Université de Lausanne Institut de Géophysique,

Switzerland, May 2007.

3. Forschungszentrum Jülich GmbH, Institute of Chemistry and Dynamics of the Geosphere, Germany, June 2007.
4. University of Wisconsin-Madison, Water Resources Seminar, February 2007 (unable to present due to flight cancellations out of State College).
5. CUAHSI-supported training course, "Fiber-Optic Distributed Temperature Sensing for Ecological Characterization," September 2007
6. USGS training course "Use of Heat as a Tracer for Surface/Ground-Water Interactions, October, 2007

ADDITIONAL FUNDING ACQUIRED USING USGS GRANT AS SEED MONEY (source, amount, starting and ending dates, title)

USGS Grant used as seed for a recent NSF-EAR proposal submission to Hydrologic Sciences: Loheide, S.P. and Singha, K. "Collaborative Research: Quantifying and manipulating stream-aquifer interactions at a stream restoration site". \$321,954. Start/end dates: 9/1/08 - 8/31/11.

The effect of oxygen availability on Fe cycling microbial communities within an acid mine drainage–induced–kill zone

Basic Information

Title:	The effect of oxygen availability on Fe cycling microbial communities within an acid mine drainage–induced–kill zone
Project Number:	2007PA74B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	9th
Research Category:	Biological Sciences
Focus Category:	Ecology, Geochemical Processes, Surface Water
Descriptors:	
Principal Investigators:	John M. Senko, Mary Ann Bruns, William Burgos

Publication

1. Senko, J. M., M. A. Bruns, W. D. Burgos. 2008. Characterization of Fe(II) oxidizing bacterial communities at two acidic Appalachian coal mine drainage impacted sites. The International Society for Microbial Ecology Journal. Submitted.
2. Senko, J. M., G. Zhang, M. A. Bruns, W. D. Burgos. 2008. Metal reduction at low pH by a Desulfosporosinus species: implications for the biological treatment of acidic mine drainage. In preparation for Geomicrobiology Journal.
3. Wanjugi, P., Bruns, M. A., Lucas, M., Senko, J. M., Burgos, W. D. 2008. A PCR–based assay for iro genes of Acidithiobacillus ferrooxidans to track population changes in acid mine drainage sediments. In preparation for Applied and Environmental Microbiology.

PRINCIPAL FINDINGS AND SIGNIFICANCE

The microbially mediated oxidative precipitation of Fe(II) from coal mine derived acidic mine drainage (AMD) is a promising strategy for the removal of that element from (AMD). The goal of this project was to elucidate microbially mediated geochemical processes associated with acidic mine drainage (AMD)-impacted sediments that lead to both the oxidative precipitation of Fe from AMD and anaerobic, reductive processes that might lead to the reversal of the desired Fe(II) oxidative process. This project was comprised of three sub-projects that included: 1) Characterization of Fe(II) oxidizing bacterial activities and communities at two acidic Appalachian coal mine drainage-impacted sites, 2) metal reduction at low pH by a *Desulfosporosinus* species, and 3) The effect of algal biomass on oxidative precipitation of Fe(II) from AMD. Each of these subprojects is described in more detail below.

Characterization of Fe(II) oxidizing bacterial activities and communities at two acidic Appalachian coal mine drainage-impacted sites

We characterized the microbiologically mediated oxidative precipitation of Fe(II) from coal mine-derived acidic mine drainage (AMD) at two sites in northern Pennsylvania. At the Gum Boot site, dissolved Fe(II) was efficiently removed from AMD whereas minimal Fe(II) removal occurred at the Fridays-2 site. Neither site received human intervention to treat the AMD. Culturable Fe(II) oxidizing bacteria were most abundant at sampling locations along the AMD flow path corresponding to greatest Fe(II) removal and where overlying water contained abundant dissolved O₂. Rates of Fe(II) oxidation determined in laboratory-based sediment incubations were also greatest at these sampling locations. Ribosomal intergenic spacer analysis and sequencing of partial 16S rRNA genes recovered from sediment bacterial communities revealed similarities among populations at points receiving regular inputs of Fe(II)-rich AMD and provided evidence for the presence of bacterial lineages capable of Fe(II) oxidation. A notable difference between bacterial communities at the two sites was the abundance of Chloroflexi-affiliated 16S rRNA gene sequences in clone libraries derived from the Gum Boot sediments. Our results suggest that inexpensive and reliable AMD treatment strategies can be implemented by mimicking the conditions present at the Gum Boot field site.

Metal reduction at low pH by a *Desulfosporosinus* species

The activity of acid-tolerant sulfate reducing bacteria (aSRB) associated with abandoned or active mine effluents may lead to the immobilization or release of environmentally harmful metals. On one hand, aSRB activity may be exploited for the removal of toxic metals from solution via enzymatic reduction of soluble metals to an insoluble form or the formation of insoluble metal sulfides or hydroxides. On the other hand, when oxidative precipitation of Mn(II) and Fe(II) is exploited for the removal of those elements from acidic mine drainage (AMD), aSRB activity may lead to the reductive solubilization of Mn(III/IV) and Fe(III) minerals. We isolated an aSRB (called GBSRB4.2) from acidic coal mine drainage-impacted sediments using medium with an initial pH of 4.2 and glucose as an electron donor and carbon source. The 16S rRNA gene sequence of GBSRB4.2 was 96% similar to that of *Desulfosporosinus orientis*. When we incubated GBSRB4.2 in a synthetic AMD (SAMD; pH 4.2) containing 10 mM sulfate, 2.5 mM dissolved Al³⁺, and H₂ as an electron donor, sulfate reduction led to an increase in SAMD pH and concurrent precipitation of dissolved Al³⁺. When we incubated GBSRB4.2 in SAMD with insoluble Fe(III) (hydr) oxide, sulfate and Fe(III) reduction occurred concurrently, leading to an increase in SAMD pH and Al³⁺ precipitation. Fe(III) reduction by GBSRB4.2 in

SO₄²⁻-free medium suggested that the Fe(III) reduction observed in SAMD was due (at least in part) to enzymatic Fe(III) reduction. Despite sulfide production, release of dissolved Fe(II) occurred as a consequence of Fe(III) reduction. When we incubated GBSRB4.2 in SAMD with Mn(IV) (hydr) oxide, Mn(II) was released into solution, but no sulfate reduction occurred. Mn(IV) reduction led to an increase in pH and precipitation of Al³⁺. GBSRB4.2 reduced U(VI) in SAMD, but sulfate was not reduced in the presence of U(VI). U(VI) reduction did not alter the pH of SAMD nor was Al precipitated. Our results indicate that aSRB activity in AMD-impacted environments may lead to the undesirable effects of soluble Fe(II) and Mn(II) release, but the desirable effects of U and Al precipitation.

The effect of algal biomass on oxidative precipitation of Fe(II) from AMD

Large blooms of acidophilic algae are often observed associated with AMD-impacted sediment. These algae represent an abundant pool of organic carbon that could profoundly influence the effectiveness of the oxidative precipitation of Fe(II) from AMD. To test the effect of algae on Fe(II) oxidation by microorganisms associated with AMD-impacted sediments, we compared rates of Fe(II) oxidation by sediments containing abundant algal biomass to those of sediments that did not contain algal biomass. First order rate constants (k) of Fe(II) oxidation in algae-free sediment microcosms were greater (k = 5.3/d) than those of algae-rich sediment microcosms (k = 3.5/d). We tested the effects of algal biomass amendment on Fe(II) oxidation by microorganisms associated with algae-free sediments by amending initially algae-free sediment incubations with algal biomass at concentrations of 0, 1, 5, and 10 g/l dry biomass. With progressively higher algal biomass concentrations, rates and extents of Fe(II) oxidation were lower. The addition of 5 and 10 g/l algal biomass to microcosms led to extensive Fe(III) and sulfate reduction, suggesting that algal biomass-derived organic carbon lead to rapid depletion of available O₂ and anoxic conditions where oxidative precipitation of Fe(II) could not be supported. Our results suggest that the abundant organic carbon provided by algal biomass may inhibit Fe(II) oxidation due to competition between organotrophic bacteria and Fe(II) oxidizing bacteria for available O₂.

STUDENTS SUPPORTED

Pauline Wanjugi, Crop and Soil Sciences, M.S.

Melanie Lucas, Civil and Environmental Engineering, M.S.

PRESENTATIONS AND OTHER INFORMATION TRANSFER ACTIVITIES

Report

Burgos, W. D., Senko, J. M., Bruns, M. A. 2008. Improving Passive Mine Treatment Through Better Understanding of Biogeochemistry and Mineralogy Associated with low-pH Fe(II) Oxidation. Commonwealth of Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, Division of Acid Mine Drainage Abatement. PA DEP_AMD 42(0420)102.1

Invited Presentations

Senko, J. M. Microbially Mediated Metal Cycling. Saint Vincent College. March 2007.

Senko, J. M. Guest Lecture, Evolution and Systematics, (BL 234), Saint Vincent College. Biogeochemistry of Early Earth.

Meeting Oral and Poster Presentations

Characterization of Fe(II)-oxidizing bacterial communities in Appalachian coal mine drainage.

Senko, J., Burgos, W., Bruns, M. European Geosciences Union General Assembly.

April 2008. Vienna, Austria.

Use of genes involved in Fe(II) oxidation to assess abundance of iron-oxidizing bacteria in acid mine drainage. Wanjugi, P., Bruns, M. A., **Senko, J.**, Lucas, M., Burgos, W. Allegheny

Branch American Society for Microbiology Meeting Abstracts. October, 2007.

Pittsburgh, PA.

Use of Fe(II)-Oxidizing Genes to Assess Iron-Oxidizing Prokaryotes in Acid Mine Drainage.

Wanjugi, P., Bruns, M. A., **Senko, J.**, Burgos, W. 2007. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International

Annual Meetings. November 2007. New Orleans, LA.

Iron Oxidizing Bacteria: Their Role in Mitigating Acid mine Drainage (AMD). Wanjugi, P.

Departmental Seminar for Crop and Soil Sciences, The Pennsylvania State University.

January, 2008, University Park, PA.

Environmental Factors Affecting Growth of Iron-Oxidizing Bacteria in Acid Mine Drainage in Northern PA. Wanjugi, P, Bruns, M. A., Senko, J., Burgos, W., Lucas, M. 2008.

Environmental Chemistry Student Symposium. April 2008. University Park, PA.

Low-pH Fe(II) Oxidation Incorporated into Passive Treatment. Burgos W. D., Senko J. M., and

Bruns M.A. 2008. West Virginia Mine Drainage Task Force Symposium. April 2008.

Morgantown, WV.

Metal reduction at low pH by a *Desulfosporosinus* species. Senko, J. M., Zhang, G., Burgos W.

D., and Bruns M. A. American Society for Microbiology General Meeting. June 2008.

Boston, MA.

ADDITIONAL FUNDING ACQUIRED USING USGS GRANT AS SEED MONEY

Pennsylvania Department of Environmental Protection. Project title: "Aeration Terraces for

Biological low-pH Iron(II) Oxidation in Acid Mine Drainage." 2007-2008. With William

Burgos and Mary Ann Bruns. \$186,392.

National Science Foundation (NSF) Emerging Topics in Biogeochemical Cycles (ETBC)

Program. "Microbial Processes to Mitigate Acid Mine Drainage from Coal Mining in

Eastern United States and China." In preparation. With William Burgos, Mary Ann

Bruns, and Hailiang Dong.

Information Transfer Program Introduction

None.

Web-Based Learning for Private Water System Owners

Basic Information

Title:	Web-Based Learning for Private Water System Owners
Project Number:	2007PA72B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	5th
Research Category:	Water Quality
Focus Category:	Groundwater, Education, Water Quality
Descriptors:	Private water system, private well, drinking water standards
Principal Investigators:	Bryan Reed Swistock, Stephanie S. Clemens, William E. Sharpe

Publication

1. Swistock, Bryan. 2007. A Quick Guide to Groundwater in Pennsylvania, Penn State College of Agricultural Sciences Publication No. UH183, 12 pp.

Principle Findings and Significance

Online Course

An online, home study course was developed for private water system owners (homeowners using an individual well, spring or cistern for a home water supply). The course includes six lessons:

- Lesson 1 – Groundwater Basics
- Lesson 2 – Private Water Supply and Conservation
- Lesson 3 – Private Water System Construction and Maintenance
- Lesson 4 – Private Water Supply Protection, Testing and Interpretation
- Lesson 5 – Solving Common Water Problems
- Lesson 6 – Private Water System Case Studies

Each Lesson includes Penn State written resources (publications, fact sheets, etc.), some optional reading materials and frequently asked questions for each topic area. The online course is currently housed and accessible at the following web site:

<http://bedford.extension.psu.edu/watersystems/watercourse.htm>

The course was offered on a pilot basis to ten homeowners beginning on October 31, 2007 and continuing for twelve weeks until January 23, 2008. Every two weeks, participants received an email introducing the upcoming Lesson along with a two minute Photostory describing what they would learn. Also attached to each Lesson's introductory email was a worksheet for the participant to complete and submit to the course instructors. The course instructors included Bryan Swistock (Water Resources Extension Specialist), Stephanie Clemens (Master Well Owner Network Coordinator), James Clark (McKean County Extension Educator), Susan Boser (Beaver County Extension Educator, Thomas McCarty (Cumberland County Extension Educator), Dana Rizzo (Westmoreland County Extension Educator, Peter Wulfhorst (Pike County Extension Educator) and Gary Micsky (Mercer County Extension Educator). The webmaster for the course is Melanie Barkley (Bedford County Extension Educator).

Groundwater Publication

To augment the available Penn State materials related to private water systems, this project funded the creation of some additional resources for inclusion in the online course. Under Lesson 1, a new publication entitled *A Quick Guide to Groundwater in Pennsylvania* was created. In September 2007, 5,250 copies of this twelve page, color publication were printed. A PDF version of the publication is also available to course participants and the public online at: <http://pubs.cas.psu.edu/FreePubs/pdfs/uh183.pdf>. Hardcopies are available free-of-charge from county Cooperative Extension offices and the College of Agricultural Sciences, Publication Distribution Center. As of September 13, 2007, 4,550 copies of the publication have been distributed statewide. There have also been several thousand downloads of this publication online.

Private Water System Management DVD

An additional resource created for the online course was a DVD video entitled *Private Water System Management*. This 30-minute DVD was professionally produced by Christopher Fagen, Inc. in State College from a script created by the course instructors. The video has five chapters, each about five to six minutes in length, which mirror the first five lessons of the online course. The individual video chapters will be included within each lesson of the course. The chapters are also available online at the following web site:

<http://www.sfr.cas.psu.edu/water/265.htm>. Three hundred copies of the 30-minute DVD have also been produced for use by Master Well Owner Network volunteers and Extension educators

throughout the state in educational programs. The DVD will also be available for \$5 (plus shipping and handling) through the College of Agricultural Sciences, Publication Distribution Center.

Results from Pilot Course Offering

An online survey was sent to each of the ten pilot participants in the course to determine impacts from the course and possible improvements before it was offered to the general public. Three participants completed the survey. All three indicated that they *“got a great deal out of the course and would enthusiastically recommend it to others”*. All three also felt that the length of the course had *“just about the right amount of material and was a bargain at \$25”*. Two of the respondents felt that the worksheets had about the right amount of detail and material while one felt that the worksheets could be more detailed. Among the respondents, the course prompted many actions to be taken on their private water supplies including testing drinking water quality, installing a sanitary well cap, identifying the wellhead protection area around their well, having a new well grouted, measuring water use and initiating water conservation. Exact comments from course participants included:

- An improvement would be to expand the number of worksheets questions/topics to create a 2-tier workload. That is, should the student want to delve deeper, have 25-100% more questions; not so much as for extra credit, as for extra knowledge. The worksheets challenged me to think and verify the answers, and I liked that learning technique.
- Worksheets could have more questions and more detail.
- I thought the program was very well done (no pun intended) the bit about the sanitary well cap was unknown to me before this course - we now have one - they are called water tight caps in Southwestern PA. I thought the course was easy to understand, covered the material I was interested in and told me how and how -to and why in regards to what I wanted to know. I would keep the same format.
- I had fun learning, in this my first on-line course. It was enlightening, informative and pleasure to participate in. As a City guy gone rural, I long knew that I needed to increase my private water system literacy. Many of the course's handouts are the essence of a homeowner's reference library. Bravo to the faculty!!!

Based on comments from participants in the pilot course, the instructors made changes to the course to reduce repetitive material, seek greater detail on worksheets, and clarify worksheet questions to reduce confusion. The course was offered to the general public beginning on April 9, 2008 and continuing through July 2, 2008. There are currently 17 participants in the private water system home study course. Improvements are continuing for the course including addition of an online water test interpretation tool that will be completed this summer.

STUDENTS SUPPORTED

- Lisa Carper, Environmental Resource Management undergraduate student
- Marie Gildow, Environmental Resource Management, B.S. May 07.

PRESENTATIONS AND OTHER INFORMATION TRANSFER ACTIVITIES

- Pilot course offered October 31, 2007 – January 23, 2008 (10 students)
- At the conclusion of the pilot course, a brochure (attached) and other newsletter publicity was created and distributed to all county Cooperative Extension offices across the state for advertisement of the online course.
- First full course offered April 9, 2008 – July 2, 2008 (17 students).

AWARDS

- None

ADDITIONAL FUNDING ACQUIRED USING USGS GRANT AS SEED MONEY

- None

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	8	0	1	0	9
Masters	3	0	0	0	3
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	12	0	1	0	13

Notable Awards and Achievements

1. The new publication A Quick Guide to Groundwater in Pennsylvania has been an instant success. Over 4550 copies of this publication have been distributed statewide in the past year and copies can also be downloaded from the Forestry Extension website. 2. The new fiber–optic distributed temperature sensing cable has proven to be very sensitive and capable of showing instantaneous patterns of temperature in a stream over time and along an entire 450 m reach of stream channel. 3. The PA Department of Environmental Protection is funding a \$186,000 project related to our pilot project to develop aeration terraces for biological, low–pH iron oxidation in acid mine drainage waters. 4. Horses and dogs were found to be the major sources of microbial contamination in Goose Creek– Chester County, PA by Dr. Metin Duran at Villanova University using fatty acid methyl ester (FAME) profiling of microbes.

Publications from Prior Years

1. 2005PA40B ("Nitrate Source Tracking: Combining Isotopic, Microbial, and Chemical Tracers in a Mixed Land–Use Watershed") – Articles in Refereed Scientific Journals – Buda, A.R. and D.R. DeWalle. xxxx. Nitrate source and flow path identification using stable isotopes in a mixed land–use karst basin. *Journal of Hydrology*.
2. 2005PA40B ("Nitrate Source Tracking: Combining Isotopic, Microbial, and Chemical Tracers in a Mixed Land–Use Watershed") – Conference Proceedings – Buda, A. Tracing sources of stream water nitrate in a central Pennsylvania mixed land–use watershed. Cleveland, OH (November 30, 2007, Cleveland State University Ecology, Evolution, and Environmental Science Seminar Series).
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